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Determinants of weight and linear growth deficits in children under two years of age

ABSTRACT

OBJECTIVE: To identify determinants of protein-energy malnutrition resulting in weight and linear growth deficits in children.

METHODS: A cross-sectional study was carried out among 1,041 children (under two years of age) from 10 municipalities in Bahia, Northeastern Brazil, during 1999-2000. Both logistic regression and a hierarchical approach were used to identify factors associated with the anthropometric measures.

RESULTS: The basic determinant found in the final model for linear growth retardation was having up to two household appliances (OR=2.9; 95% CI: 1.74-4.90); as an underlying determinant, not attending prenatal visits (OR=2.7; 95% CI: 1.47-4.97); and, among immediate determinants were low birth weight (OR=3.6; 95% CI: 1.72-7.70) and reported hospitalization within 12 months before the interview (OR=2.4; 95% CI: 1.42-4.10). Determinants of weight deficit at the basic, underlying and immediate levels were: per capita monthly income of less than one-fourth of the minimum wage (OR=3.4; 95% CI: 1.41-8.16), not attending prenatal visits (OR=2.1; 95% CI: 1.03-4.35) and low birth weight (OR=4.8; 95% CI: 2.00-11.48) respectively.

CONCLUSIONS: Children's weight and linear deficits were accounted for the overlapping of poor material living conditions, limited access to health care and disease burden. Interventions aimed at improving living conditions and better access to health care programs are strategies towards equity in children's health and nutrition.

KEYWORDS: Protein-energy malnutrition. Infant. Body weights and measures. Risk factors. Social conditions. Cross-sectional studies.

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INTRODUCTION

The first years of life constitute the most dynamic phase in the process of growth during childhood and are highly vulnerable to social, economic and environment conditions.¹⁸ Malnutrition during childhood is a major health concern in developing countries.

It is estimated that 38.1% of children under five have severe deficit in the height-to-age anthropometric measure and 31% have severe deficit of the weight-to-age measure.²¹

A few countries show now a declining trend in the prevalence of protein-energy malnutrition during childhood,²¹ including Brazil.¹⁶ Brazilian population has now a 5.7% weight deficit and 10.5% linear growth deficit¹⁶ showing different geographic distributions. The prevalences of weight-to-age and height-to-age deficits in the Northeastern region are 8.3% and 17.9%, respectively, while in the Southern region are 2% and 5.1%, respectively. The gaps in anthropometric measures of Brazilian children between country regions have been explained by different levels of social and economic development as well as investments in sanitation, health care and education.¹¹

The United Nations Fund for Childhood⁵ (Unicef) categorizes the causes of protein-energy malnutrition during childhood into hierarchical levels. For better understanding this event, Unicef recommends a model based on three explanatory levels including basic, underlying, and immediate determinants.

In this model, structural or basic determinants are represented by indicators of access to the resources needed for survival available in the community, reflected in the population's socioeconomic conditions.² This set of determinants interfaces with intermediate or underlying determinants, which are included in the second hierarchical level of the model and relate to the number and quality of care services provided by the government and to the ability of families to use them. In the third level of the hierarchical model immediate determinants are included, reflecting children's health and nutritional status. These determinants are conditioned, on one hand, by basic causes directly expressed by the family's economic condition and, on the other hand, by the extent to which children's health care needs are met and care is provided by the family and by primary care services available in the community.²⁰

The four determinants of malnutrition in Brazil, especially in the Northeastern region, are well-known but they have not often been studied using a hierarchical approach. Thus, the present study aimed at describing determinants of weight and linear growth deficits in children based on a hierarchical approach with different explanatory levels for determining health and nutritional status during childhood.

METHODS

A cross-sectional study comprising a sample of 1,041 children under two years of age, originally selected for a larger study, was carried out between March 1999 and 2000. The study aimed at assessing health and nutritional status of preschool children living in 10 municipalities of the state of Bahia, Northeastern Brazil.*

The sample size estimate was based on the number of children under five years of age living in rural and urban areas of the municipalities sampled in the 1996 Brazilian Census Survey,** and on the prevalence of child malnutrition in the Northeastern region (8.3% for weight-to-age measure) estimated in the National Demographic and Health Survey (PNDS).¹⁶ Hence, a sample size of 2,733 preschool children was estimated and those 1,041 children under two years of age were included in the study.

Taking into account the most significant associations of basic determinants of malnutrition, the sample of 1,041 children under two included in the study had 84% power to identify the association between anthropometric deficit according to weight-to-age measure and per capita family income, and 98% power to assess the relationship between height-to-age measure and the number of household appliances. A 0.05 statistical significance level (α) was set.

The 10 municipalities studied were randomly selected among those with a population between 10,000 and 15,000 inhabitants, a criterion established to meet procedural requirements of the study. Systematic sampling was conducted by conglomerate and in multiple stage and all children under five living in the households selected were included in the study.

Anthropometric, socioeconomic, demographic and environment information and data related to families, mothers and their children were collected by trained interviewers visiting the households. Stand-

*Assis AMO, Barreto ML, Neves RBB, Castro RF, Costa LCC, Mercês CF, et al. Indicadores socioeconômicos no diagnóstico e planejamento em saúde e nutrição. Salvador: UFBA/Escola de Nutrição/Instituto de Saúde Coletiva; 2000.

**Instituto Brasileiro de Geografia e Estatística - IBGE. Contagem populacional, 1996. Disponível em <http://www.ibge.gov.br/home/estatistica/populacao/contagem/bacont96.shtm> [acesso em 28 ago 2005]

ard and pre-coded questionnaires were administered to the child's mother or caregiver.

Weight was measured using a 100-g precision portable microelectronic scale (Fillizola, Model E-150/3P). Height was measured using a wood measurement scale for children, especially built for this purpose. Measures were taken in duplicate and final measures were estimated as the average of the two measures taken. It was accepted 100-g and 0.1-cm error for weight and height measures, respectively. Measures were taken according to established technical requirements.¹⁰ Anthropometric measures such as weight to age and height to age were included as dependent variables. Children whose anthropometric measures (in z-scores) fell below -2 standard deviations (SD) of the average for the reference population were classified as malnourished and anthropometric measures equal to or above -2 SD were classified as eutrophic.

Variables related to basic determinants of malnutrition were as follows: per capita family income, categorized as <0.25 (considered a risk factor), 0.25-0.49, and ≥ 0.50 minimum wages; household appliances (including the following items: stove, refrigerator, radio, and television set), categorized as 4, 3 and ≤ 2 (considered a risk factor); maternal schooling, categorized as illiterate (considered a risk factor), elementary, middle, high school, and university education; and maternal occupation, categorized as yes (considered a risk factor) and no (Figure).

Variables related to underlying determinants were designated by the environment index, adapted from Issler & Giugliani⁹ study, and constructed based on 11 items properly weighed indicating physical and environment conditions of the household and its surroundings. The higher the score the better the living environment for a child and his/her family. The environment index was classified in terciles. As for studying the mothers, the selected variables were: number of prenatal visits, categorized as zero, 1-5 and ≥ 6 (considered a protection factor) (Figure).

Immediate determinants included child-related factors as follows: age, categorized as <6, 6-12 and 12-24 months (higher susceptibility to malnutrition); gender, categorized as male and female (considered a risk factor), birth weight (<2,500 g was considered a risk factor), presence of any health condition in the 15 days prior to the interview (based on mother's reporting of diarrhea, fever, vomiting, coughing, loss of appetite, discharge of worms, ear or throat aches and weariness or sadness) and history of hospitalization in the 12 months prior to the interview (Figure).

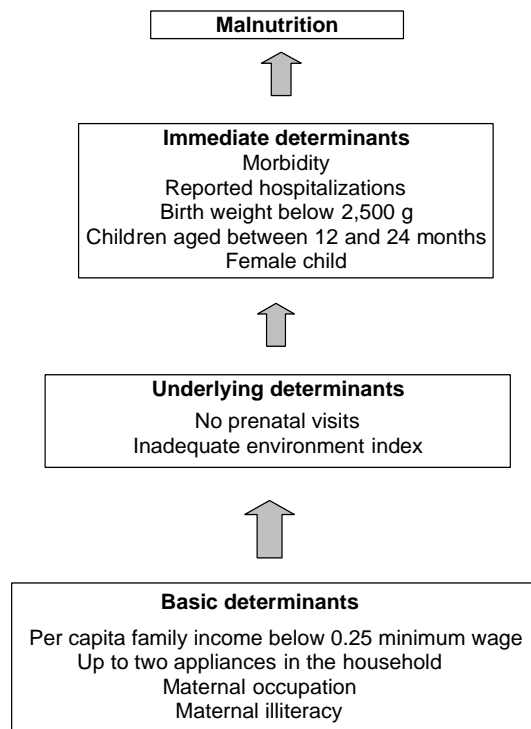


Figure - Hierarchical model of malnutrition determinants during childhood. Bahia, Northeastern Brazil, 1999-2000.

Prevalence was used to describe the population according to relevant variables. Multiple logistic regression analysis was conducted to identify determinants of malnutrition.

Colinearity was assessed using the variance inflation factor (VIF), and VIF values below 10 indicated no colinearity.⁸ A significance level of less than 0.05 was established to accept the associations studied.

The model was first constructed including variables related to basic determinants of malnutrition. Those statistically significant ($p < 0.05$) variables were included as basic determinants and contributed to adjusting the subsequent blocks of analysis. A second model consisted of variables of underlying causes. First it was constructed a model including all variables of this block. Then those variables showing statistical significance ($p < 0.05$) were subsequently adjusted to basic determinants. In a third step of the analysis, variables of the immediate determinant block were included. Those variables statistically significant ($p < 0.05$) were then adjusted to basic and underlying determinants and to immediate variables of this block. The variables of each step of the analysis were included in the construction of the final model. It should be noted that the variable child's gender was not excluded in this step of the analysis though it was not statistically significant ($p < 0.05$) because of its role as a potential confounder of the association studied.

Table 1 - Anthropometric characterization of children under two living in municipalities of the state of Bahia, Northeastern Brazil, 1999-2000. (N=1,041)

Variable	N	%
Height-to-age		
Malnutrition (<-2DP)	132	12.4
Eutrophy (≥-2DP)	909	87.6
Weight-to-age		
Malnutrition (<-2DP)	81	7.8
Eutrophy (≥-2DP)	960	92.2

As a multiple stage design was used in the study, the conglomerate effect on inferences about standard error of estimates was taken into consideration in the statistical analysis.

Data was doubled entered using Epi Info 6.0 software program. Anthropometric status was evaluated using

ANTHRO program. Stata package was used in the analysis as it includes the conglomerate effect on standard error of estimates.

The study ethical appropriateness was approved by the Research Ethics Committee of the Instituto de Saúde Coletiva of Universidade Federal da Bahia. Following the ethical principles regulating human research, those children diagnosed as malnourished were referred to health services for required medical care.

RESULTS

The anthropometric status assessment for height-to-age measure indicated that 12.4% of children had deficits below -2 SD of the mean for the reference population. Similarly, the prevalence of the anthro-

Table 2 - Crude odds ratio for determinants of height-to-age and weight-to-age deficits in children under two living in municipalities of the state of Bahia, Northeastern Brazil, 1999-2000. (N=1,041)

Variable	N	%	Height-to-age OR crude (95% CI)	Weight-to-age OR crude (95% CI)
Basic causes				
Per capita income (MW)				
≥0.50	186	54.9	1.0	1.0
0.25-0.49	269	26.0	1.9 (0.8-4.3)	1.1 (0.4-3.2)
<0.25	586	19.1	3.2 (1.6-6.6)	3.4 (1.4-8.2)
Household appliances				
4	353	36.0	1.0	1.0
3	270	26.8	2.1 (1.2-3.8)	2.1 (1.0-4.2)
≤2	416	37.2	2.9 (1.7-4.9)	2.6 (1.4-4.8)
Maternal schooling				
High school and university	193	19.8	1.0	1.0
Middle school (compl/incompl)	265	27.0	1.4 (0.7-3.0)	1.3 (0.5-3.2)
Elementary school (compl/incompl)	467	43.3	2.5 (1.3-4.7)	2.0 (0.9-4.4)
Illiterate	117	9.9	4.2 (2.0-8.9)	4.3 (1.8-10.2)
Maternal job				
No	843	81.4	1.0	1.0
Yes	198	18.6	1.1 (0.7-1.8)	1.9 (0.9-4.0)
Underlying causes				
Environment index				
Adequate	352	33.9	1.0	1.0
Semi-adequate	353	33.9	1.8 (1.0-3.1)	1.6 (0.8-3.3)
Inadequate	335	32.2	3.0 (1.8-5.0)	3.1 (1.6-5.8)
Prenatal care visits				
Yes	780	77.4	1.0	1.0
No	259	22.6	2.4 (1.6-3.5)	2.6 (1.6-4.3)
Number of prenatal care visits				
≥6	355	35.1	1.0	1.0
1-5	397	39.3	2.2 (1.3-3.8)	1.4(0.7-2.7)
None	259	25.6	3.7(2.1-6.4)	3.1(1.7-5.9)
Immediate causes				
Health condition*				
No	357	65.6	1.0	1.0
Yes	681	34.4	1.0(0.7-1.6)	2.0(1.1-3.7)
Hospitalization**				
No	896	86.3	1.0	1.0
Yes	142	13.7	2.1(1.2-3.1)	2.0(1.1-3.5)
Birth weight***				
≥2,500 g	897	94.9	1.0	1.0
<2,500 g	44	5.1	3.8(1.8-8.0)	5.0(2.3-11.0)
Age (months)				
<6	256	23.6	1.0	1.0
6 —12	253	24.4	1.1(0.6-2.0)	2.5(0.9-7.2)
12 — 24	532	5.1	1.7(1.0-2.8)	5.9(2.4-14.5)
Gender				
Male	523	50.2	1.0	1.0
Female	518	48.8	0.8 (0.6-1.2)	1.2 (0.74-1.9)

Some variables do not total N=1,041 due to missing information or data inconsistencies.

*In the 12 months prior to the study

**In the 15 days prior to the study

***As per mother's reporting

ometric deficit for the weight-to-age measure was 7.8% (Table 1).

Simple logistic regression analysis showed that per capita monthly family income below 0.25 minimum wages, a basic determinant of malnutrition, was significantly associated to height-to-age and weight-to-age deficits compared to a reference of more than 0.5 minimum wages. Increasing statistically significant associations for both weight-to-age and height-to-age deficits were seen for children living in households with up to three appliances when compared to those living in households with four or more appliances. Also, as part of basic determinants, lower maternal schooling was associated to weight and linear growth deficits in the children studied (Table 2).

Of the underlying determinants, inadequate environment conditions were a limiting factor for weight and linear growth in the children studied. Children whose mothers did not attend prenatal visits were more likely to have height-to-age and weight-to-age deficits when compared to those whose mothers attended prenatal care.

It was also found that children whose mothers did not attend any prenatal visit had higher risk for height-to-age and weight-to-age deficits than those whose mothers attended six or more visits (Table 2).

In regard to immediate determinants, having a health

condition in the 15 days prior to the interview was associated to weight-to-age deficit. Reported hospitalization in the 12 months prior to the interview was associated to weight and height deficit in the children studied. In this same block, low birth weight was significantly associated to height-to-age and weight-to-age deficits when compared to adequate birth weight. In addition, odds ratio for both height-to-age and weight-to-age deficits were higher in children aged 12-24 months compared to those aged zero to six months (Table 2).

The final models including the determinants of height-to-age and weight-to-age deficits are presented in Table 3. The number of appliances in a household, representative of the basic hierarchical level, was found to be associated to linear growth deficit. Children living in households where there were three appliances were 2.1 (95% CI: 1.19-3.83) more likely to have linear growth deficit; this likelihood increased to 2.9 (95% CI: 1.74-4.90) when the number of appliances in a household dropped to two or less (Table 3).

As for the underlying determinants, it was verified that children whose mothers did not attend any prenatal care visits were 2.7 (95% CI: 1.47-4.97) more likely to have linear growth deficit, and this likelihood fell to 1.9 (95% CI: 1.09-3.34) when mothers attended one to five visits. Children who were hospitalized in the 12 months prior to the interview, an immediate determinant, were 2.4 (95% CI: 1.42-4.10)

Table 3 - Final hierarchical model of anthropometric deficit according to height-to-age and weight-to-age measures in children under two living in municipalities of the State of Bahia, Northeastern Brazil, 1999-2000. (N=1,041)

Model	OR adj	Height-to-age 95% CI(OR)	p-value	OR adj	Weight-to-age 95% CI(OR)	p-value
Basic causes						
Per capita income (MW)						
≥0.50	-	-	-	1.0	-	-
0.25-0.49	-	-	-	1.1	0.39-3.21	0.832
< 0.25	-	-	-	3.4	1.41-8.16	0.006
Household appliances						
4	1.0	-	-	-	-	-
3	2.1	1.19-3.83	0.011	-	-	-
≤2	2.9	1.74-4.90	0.000	-	-	-
Underlying causes						
Number of prenatal care visits						
≥6	1.0	-	-	1.0	-	-
1-5	1.9	1.09-3.34	0.023	1.1	0.53-2.21	0.812
None	2.7	1.47-4.97	0.001	2.1	1.03-4.35	0.039
Immediate causes*						
Hospitalization**						
No	1.0	-	-	-	-	-
Yes	2.4	1.42-4.10	0.001	-	-	-
Birth weight***						
≥2,500 g	1.0	-	-	1.0	-	-
<2,500 g	3.6	1.72-7.70	0.001	4.8	2.00-11.48	0.000
Child's age (months)						
<6	-	-	-	1.0	-	-
6 —12	-	-	-	2.6	0.84-8.14	0.094
12 — 24	-	-	-	4.8	1.80-13.06	0.002

Some variables do not total N=1,041 due to missing information or data inconsistencies.

*Adjusted by the variable gender

**In the 12 months prior to the study

***As per mother's reporting

more likely to have linear growth deficit compared to those who were not hospitalized. Besides, it was found that low birth weight remained highly associated with linear growth deficit (OR=3.6; 95% CI: 1.72-7.70) compared to adequate weight at birth ($\geq 2,500$ g) (Table 3).

For assessing weight growth deficit, per capita family income was included in the final model as a basic determinant. It was noted that weight deficit was 3.4 (95% CI: 1.41-8.16) more likely in children of families with an income below 0.25 minimum wage than in those of families with an income ≥ 0.5 minimum wage.

In the hierarchical block of underlying determinants, children whose mothers did not attend any prenatal care visits were 2.1 (95% CI: 1.03-4.35) more likely to have inadequate weight-to-age compared to children whose mothers attended six or more visits during pregnancy (Table 3).

Immediate determinants of children's weight deficit are birth weight and age ≥ 12 months. Those with low birth weight were 4.8 (95% CI: 2.00-11.48) more likely to have weight growth deficit compared to those with adequate weight and those having between 12 and 24 months were 4.8 (95% CI: 1.80-13.06) more likely to have weight deficit than those under six months of age (Table 3).

DISCUSSION

Growth is a life event highly sensitive to the social, economic, and environment conditions of children and their family, pointing out to the epidemiological relevance of basic determinants in the hierarchical level in determining health and nutritional status during childhood. Poverty, assessed through family income of children participating in the study, was associated to weight-to-age deficit in the first two years of life. Hence, per capita family income below 0.25 minimum wages certainly limits these families' purchase power and prevents them from meeting their material needs, making children living at this level of poverty highly vulnerable to weight deficits.

This level of family income also reduces their access to household appliances and, thus, explains the association found between the number of appliances in a household and children's height-to-age deficit in this study as well as in other studies.⁷ The number of appliances in a household may provide a stronger explanatory implication for these children's linear growth deficit than income per se. Having some appliances at home makes a difference to the material

life condition of these children and their families. Therefore, having no appliances or a limited number of appliances at home can limit the maintenance of their hygiene conditions and restrict their access to information, playing an adverse role and compromising health and nutritional status during childhood.⁴

Poor life conditions, included in the basic hierarchical level for explaining malnutrition, interact with factors in the underlying level and determine a family's ability to use health services available.

This scenario is illustrated by the number of prenatal care visits during pregnancy and having adequate weight-to-age and height-to-age. The interaction resulting from these factors is reflected in the immediate determinants and can explain the association found between low birth weight and weight and linear growth deficits. And it reveals that the quality of prenatal care and follow-up provided to the mothers in this study do not incorporate the comprehensive dimensions of care proposed by the Brazilian Ministry of Health.

Low birth weight seen in the present study (5.1%, Table 2) was lower than that recently found nationwide (9.2%)¹⁶ and similar to that seen in developed countries (5% to 6%).²¹ However, it is epidemiologically relevant as a strong predictor of post-natal growth, especially because linear growth deficit can arise early in the intrauterine life.³

Also in regard to immediate determinants, it should be underlined the role of prior hospitalization as an adverse factor for adequate linear growth during childhood. In the first two years of life, children are mostly hospitalized due to infectious diseases, especially diarrhea and respiratory infections. The synergistic effect between malnutrition and infection is translated into the highest disease burden and mortality rates among malnourished children.¹³ Bearing in mind the potential bidirectionality between disease burden and child malnutrition, and also taking into account that the design of the present study does not allow to establishing a relationship between them, the study results indicate that health conditions requiring hospitalization prevents adequate linear growth during childhood. Similar findings were reported by other authors in cohort studies, a design that is more adequate to explore this relationship.^{1,17}

Being in the 12-24 months age group was another variable found to be associated to weight deficit. Similar findings were reported by other researchers.^{12,16} Several hypotheses can be made to explain these children's higher susceptibility to malnutrition in the first

months of extra-uterine life, among them early weaning, inadequate consumption of supplementary food, and low coverage and low quality of public health actions provided to this population.¹

Despite anthropometric surveys in Brazil have revealed substantial improvement of Brazilian children anthropometric status, such improvement has not been either even or widespread in this population.¹¹ There still can be noted higher weight deficits in preschool children in the Northern (7.7%) and Northeastern regions (8.3%) than in the Southern region (2%). A similar trend can also be observed for height-to-age deficit in the Northern (16.2%) and Northeastern regions (17.9%) compared to that seen in the Southern region (5.1%). Clearly, these higher rates reflect local conditions in these regions, where children are living in a situation of social and economic insecurity, which is also reflected by their limited chances of survival.¹⁹

The hierarchical approach used in the present study is also limited regarding determinants of health events during childhood, since they have different levels of interdependency.¹⁵ Yet the study has already incorporated advances compared to the traditional models of multiple logistic regression analysis. In this context, the study results indicate there are social gaps and health and nutritional inequalities for most children under two in the municipalities studied. They also evidenced the large gap to be bridged in the quest for social, economic and nutritional security for an expressive share of the Brazilian population, especially those living in the Northeastern region.

Although the statistical model constructed was adjusted to most factors that could potentially interfere

with the anthropometric status of children studied, the cross-sectional design has intrinsically important limitations. For instance, it does not allow any temporal assumptions, which are particularly relevant in determining the length of time of variable exposure on the outcome,¹⁴ commonly seen in the study of malnutrition determinants. And so a cross-sectional design does not allow to establish a cause-effect relationship between the events studied but only to observe associations between events. Thus, the positive or negative association seen in the present study should not be understood as a risk or protection factor for malnutrition.

Although the study cross-sectional design has been carefully developed and a robust statistical method has been applied, the results obtained have limited application for children living in municipalities with different social, economic and demographic characteristics, where different life conditions favor distinct growth curves during childhood.

Regardless of the study limitations, the study results provoke thought on the concerns of international organizations to retake the discussion about measuring social and economic inequalities in developing countries and their impacts on health and nutrition.⁶ In this sense, it should be stressed the need for implementing specific action in health and nutrition for preventing malnutrition and reducing disease burden during childhood. It is also highlighted the need for interventions targeted to reduce poverty and the gap between the poor and well-off populations, by providing them a level of social and economic security that could culminate in health and nutrition equity for Brazilian children and their families.

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